PROBABILISTIC REGIONS OF PERSISTENCE

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Abstract

Perhaps the most difficult, and certainly the most intensely studied problem in temporal reasoning is the persistence of information—that is, what reasonable inferences can we draw about non-change given partial knowledge of the world and of the changes taking place. Almost all previous work hinges on McCarthy's common sense law of inertia (CSLI): things tend not to change. The obvious consequence of adopting this view is that it becomes reasonable to infer that the duration of non-change is arbitrarily long. For instance, a typical inference in systems that appeal to CSLI is that if a person is alive now, the person will remain alive (arbitrarily long) until something happens that results in the person's death.

We describe a framework that allows a more realistic treatment of persistence by incorporating knowledge about the duration of persistence of information. Inferences, such as a wallet dropped on a busy street tends to remain where it fell for a shorter duration than a wallet lost on a hunting trip, can be drawn in this framework. Unlike the CSLI approach, this inference is possible without knowing what happened to change the wallet's location. We accomplish this by casting the problem of how long information persists as a problem in statistical reasoning.

1. INTRODUCTION

A popular method in AI for representing and reasoning about temporal domains is to define a first order logic that includes some representation for time. For example, the logic may represent time by using a discrete structure such as the integers or a dense
structure such as the reals. Since the world is continuous, we are interested in logics that view time as being linear and dense (e.g., the reals).

A logic for reasoning about temporal domains must deal with the persistence problem, that is, what reasonable inferences can we draw about non-change given partial knowledge of the world and of the changes taking place. For instance, if \( p \) is true at some point or over some interval, and nothing that affects \( p \) is known to occur, is it reasonable to infer that \( p \) holds outside the interval in which it is known to hold? More concretely, if "the house is red" is known to be true over the interval (5,10) and we know of nothing that could affect the color of the house, then is it reasonable to assume that "the house is red" persists outside the interval (5,10), say over the interval (1,20)?

Almost all previous work on persistence hinges on McCarthy's common sense law of inertia (CSLI): things tend not to change. The obvious consequence of adopting this view is that it becomes reasonable to infer that the duration of non-change is arbitrarily long. For instance, a typical inference in systems that appeal to CSLI is that if a person is alive now, the person will remain alive (arbitrarily long) until something happens that results in the person's death.

Here we describe a framework that allows a more realistic treatment of persistence by incorporating knowledge about the duration of persistence of information. Inferences, such as a wallet dropped on a busy street tends to remain where it fell for a shorter duration than a wallet lost on a hunting trip, can be drawn in this framework—unlike the CSLI approach, this inference is possible without knowing what happened to change the wallet's location. We accomplish this by casting the problem of how long information persists as a problem in statistical reasoning.

2. THE PERSISTENCE PROBLEM

The persistence problem has a long history in AI and has been intensely studied (e.g., [Brown87, Pylyshyn87, Ford91]). It evolved out of the frame problem—how to succinctly state, reliably predict, and efficiently compute non-change in the context of a particular temporal logic: situation calculus [McCarthy69]. In our view, the term "persistence problem" has come to mean "the frame problem in context of any temporal logic" (cf. [Shoham87]), although attention to "efficient computation" seems to have diminished. Here our focus is on the prediction component of the persistence problem: what reasonable inferences can we draw about non-change given partial knowledge of the world and of the changes taking place.

There are at least three aspects to the prediction component of the persistence problem:

1. the kind of information that persists,
2. the direction of persistence on the timeline and
3. the extent of persistence.

Let's consider each issue in turn.

The first issue, what kind of information persists, depends on what kind of information there is, i.e., it depends on the ontology. In a "continuous" temporal logic, we are generally